

DETERMINING SPEECH RECEPTION THRESHOLD

CROSS-REFERENCE TO RELATED APPLICATION

This patent application incorporates by reference in its entirety the subject matter of the currently co-pending U.S. Patent Application entitled, CALIBRATING
 5 AUDIOMETRY STIMULI, naming William A. Ahroon as inventor, filed substantially contemporaneously herewith.

This patent application incorporates by reference in its entirety the subject matter of the currently co-pending U.S. Patent Application entitled, DETERMINING
 10 SPEECH INTELLIGIBILITY, naming William A. Ahroon as inventor, filed substantially contemporaneously herewith.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with government support provided by the United States Army. The government has certain rights in this invention.

15 BACKGROUND OF THE INVENTION

Field of the Invention

The present application relates, in general, to audiometry. The present application relates, in particular, to speech audiometry.

Description of the Related Art

20 Audiometry is the testing of hearing acuity by use of an audiometer. An audiometer is an instrument for gauging and recording the acuity of human hearing.

There are various types of testing used in audiometry (*e.g.*, pure-tone testing, or speech-based testing). In pure-tone testing, a person is usually fitted with headphones or positioned between speakers, and thereafter a series of single-tone (or

frequency) sounds are played back through the headphones or speakers. The person's responses to the played-back sounds are recorded (typically by a human tester, but sometimes by machine), and an assessment of the person's hearing acuity is made on the bases of the person's responses. In speech-based testing, like in pure-tone testing, a person
5 is usually fitted with headphones or positioned between speakers. However, unlike pure-tone testing, in speech-based testing a series of spoken words are played back through the headphones or speakers. The person's responses to the played-back words are recorded (typically by a human tester), and an assessment of the person's hearing acuity is made on the bases of the person's responses.

10 One type of speech-based testing is speech reception threshold (SRT) testing. SRT testing generally provides a measure of sound intensity (in decibels (dB), which is related to the "loudness" of speech as perceived by humans) at which words become intelligible. In typical SRT testing, a person whose hearing is being tested is usually fitted with headphones or positioned between speakers, and thereafter a series of
15 words known as "spondees" (two syllable words with equal stress on each syllable (*e.g.*, "baseball")) are played through the headphones or speakers. In between the playback of each spondee, the individual conducting the SRT testing typically adjusts the sound intensity, or loudness, up or down until the person's responses to the played-back words are consistently meeting criteria which indicate that the sound intensity is at just the level
20 necessary for speech to be intelligible (those skilled in the art will recognize that what such criteria are will vary depending upon the testing protocol being utilized).

BRIEF SUMMARY OF THE INVENTION

The inventor had devised a method and system which improve upon related-art Speech Reception Threshold Testing.

25 In one embodiment, a method includes but is not limited to presenting at least one calibrated spoken word; and measuring a speech reception threshold utilizing the at least one calibrated spoken word.

In another embodiment, the presenting at least one calibrated spoken word is characterized by presenting the at least one calibrated spoken word having root-mean-squared calibration.

In another embodiment, the presenting at least one calibrated spoken word is characterized by presenting the at least one calibrated spoken word having peak value calibration.

In one or more various embodiments, related systems include but are not limited to circuitry and/or programming for effecting the foregoing referenced method embodiments; the circuitry and/or programming can be virtually any combination of hardware, software, and/or firmware configured to effect the foregoing referenced method embodiments depending upon the design choices of the system designer.

The foregoing is a summary and thus contains, by necessity; simplifications, generalizations and omissions of detail; consequently, those skilled in the art will appreciate that the summary is illustrative only and is NOT intended to be in any way limiting. Other aspects, inventive features, and advantages of the devices and/or processes described herein, as defined solely by the claims, will become apparent in the non-limiting detailed description set forth herein.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

Figures 1A-1E, show, among other things, an environment wherein processes described herein may be implemented

Figure 2 shows a high-level logic flowchart depicting a process.

Figure 3 shows an implementation of the high-level logic flowchart shown in Figure 2.

Figure 4 shows an implementation of the high-level logic flowchart shown in Figure 2.

Figure 5 shows an implementation of the high-level logic flowchart shown in Figure 2.

Figure 6 shows an implementation of the high-level logic flowchart shown in Figure 2.

Figure 7 shows an implementation of the high-level logic flowchart shown in Figure 2.

5 Figure 8 shows an implementation of the high-level logic flowchart shown in Figure 2.

Figure 9 shown are alternate implementations of the high-level logic flowchart shown in Figure 2.

The use of the same reference symbols in different drawings indicates
10 similar or identical items.

DETAILED DESCRIPTION OF THE INVENTION

As described in the “description of related art section”, above, in related-art SRT testing a person whose hearing is under test typically is exposed to a series of spondees, where the test administrator adjusts the sound intensity of the presented words up
15 or down until the responses of the person whose hearing is under test consistently meets criteria which indicate that the sound intensity is at just the level necessary for speech to be intelligible.

The inventor has discovered the heretofore unrecognized fact that related-art SRT testing has inaccuracies arising from lack of precision with respect to exactly what the
20 person whose hearing is being tested is exposed to, and that this lack of precision impacts upon the efficacy of the related-art SRT testing as well as the reproducibility of the related-art SRT testing. Accordingly, the inventor has devised methods and systems which remedy the lack of precision of the related-art SRT testing, and correspondingly give an increase in the efficacy and reproducibility of SRT testing.

25 The inventor has noticed that, as regards words presented to an individual undergoing SRT testing, while the *loudness* at which the system through which the words are being played back is controlled (*e.g.*, the gain of amplifier driving the speakers or headphones through which the words are being played back), there is typically *no (or very*

little) control over the energy (or intensity, or loudness) of the played-back words themselves. Consequently, the inventor has recognized that, insofar as SRT testing is primarily based upon variations of the loudnesses of words played back to a person whose hearing is being tested, the fact that the played-back words themselves may have been
5 recorded (or captured) with different energies (or intensities, or loudnesses) will introduce inaccuracies into the SRT testing in that such differences in loudnesses can often somewhat offset the adjustment of the playback gain by the tester during testing. An extreme example of the foregoing would be where a first spondee (*e.g.*, baseball) was spoken and recorded in a normal tone of voice, and a second spondee (*e.g.*, armchair) was spoken and
10 recorded in a shouted tone of voice. Assuming the recording equipment itself were not altered between recording the two spondees, upon playback "armchair" would be perceived as appreciably louder than "baseball," even if the gain of the playback system were kept constant across the two played-back words. The inventor has discovered that, in the case of SRT testing, where loudnesses between different words is primarily the basis for test
15 assessment, such variations in the loudnesses or energies of the played-back words can become significant.

In light of the foregoing, the inventor has devised methods and systems whereby words used in SRT testing are "calibrated" such that the words have substantially the same sound energy – at least as viewed against some common scale – which thus
20 insures that the SRT testing measures speech reception across words having the same or similar energies. As will be discussed following, two of the common scales which the inventor has used to calibrate the words are the Root Mean Squared (RMS) energies of a waveform representative of the words (*e.g.*, a computer data file containing binary information representative of a voltage waveform produced by a microphone), and positive
25 peak values of the waveforms representative of the words (*e.g.*, a computer data file containing binary information representative of a voltage waveform produced by a microphone). However, it is to be understood that the methods and systems utilized herein are not limited to such scales. Rather, the methods and systems utilized herein may be

extended to like systems where the words played back in an SRT test are calibrated against a common scale.

With reference to the Figures, and in particular with reference now to Figures 1A-1E, shown, among other things, is an environment wherein processes described herein may be implemented. With reference now to Figure 1A, shown is a view of data processing system 120 as it might appear if it were being accessed by a human operator (not shown) of a computer program running internal to system unit 122. Illustrated is graphical user interface (GUI) 145 appearing on video display device 164, with which the human operator may interact via some or all of keyboard 166, mouse 170, and microphone 168. Those skilled in the art will appreciate that in operation human test subject 100 (see Figure 1B) and the human operator (not shown in Figure 1A) would typically see and interact with different display devices (e.g., as shown in Figures 1A and 1B, respectively). Those skilled in the art work also appreciate that system unit 122 of data processing system 120 may be configured, using equipment and techniques well-known to those having ordinary skill in the art, to drive the two different display devices 164, 124, and accept input from the two different mice 170, 128, respectively shown in Figures 1A and 1B. In Figure 1A, GUI 145, video display device 164, mouse 170, and microphone 168 are all under the control of a computer program running internal to system unit 122. Those skilled in the art will recognize that system unit 122 typically houses one or more processors, communications, and memory devices. In Figure 1A, GUI 145 depicts what in one implementation a human program operator (or test conductor) sees when a computer program running internal to the data processing system 120 is executing a program which helps administer ^{a modified bit 1210101} Hughson-Westlake procedure as described herein.

Referring now to Figure 1B, depicted is human test subject 100 interacting with graphical user interface (GUI) 125 appearing on video display device 124 via mouse 128 (which human test subject 100 is holding). Illustrated is that human test subject 100 is wearing headphones 140. GUI 125, video display device 124, mouse 128, and headphones 140 are all under the control of a computer program running internal to a data processing system unit 122. GUI 125 depicts what in one implementation human test subject 100 sees

when a computer program running internal to system unit 122 is executing a program which administers the Parameter Estimation by Sequential Testing (PEST) procedure as described herein. In one implementation of the PEST procedure human test subject 100 will indicate the word he has heard through headphones 140 via using mouse 128 to “click”
5 on the appropriate word of GUI 125. Those skilled in the art will appreciate that during the Hughson-Westlake procedure human test subject 100, rather than interacting with a GUI, will recite back to a test conductor the word which human test subject 100 believes he has heard through headphones 140, and thus that when human test subject 100 is undergoing the Hughson-Westlake procedure it is possible that video display device 124 will not be
10 present.

With reference now to Figure 1C, shown is a close-up view of GUI 145 of Figure 1A. As discussed previously, GUI 145 is representative of a GUI which can be used with what is known in the art as a modified Hughson-Westlake testing paradigm. The
15 screen shown in Figure 1C is basically analogous to an audiometer typically used in pure-tone testing using a Hughson-Westlake procedure, and the loudness controls of GUI 145 will be adjusted as appropriate during modified Hughson-Westlake testing, much in the same way the audiometer would be adjusted during pure-tone testing. GUI 145 shows the setup and screen used by the test conductor during the modified Hughson-Westlake
20 procedure.

Referring now to Figure 1D shown is a close-up view of a third GUI 155. As described above, and further in light of the disclosure herein, those having ordinary skill in the art will recognize that GUI 155, as shown in Figure 1D, is representative of a GUI which will be seen by the operator when the (PEST) procedure is being utilized. Illustrated
25 are adjustable GUI fields labeled “Initial Attenuation (dB),” “Initial Step Size (dB),” and “Criterion,” which can be adjusted by the audiologist or tester by pointing and clicking on the up and down arrows associated with the adjustable GUI fields. Shown are adjustable GUI fields having the test subject’s Last Name, First Name, and ID Number, as well as notes related to any special testing conditions.

Referring now to Figure 1E, shown is a close-up view of GUI 125, which as described above shows PEST procedure response screen. Depicted is that GUI 125 has a number of clickable controls, with each control labeled with a spondee (*e.g.*, the icons labeled "airplane", "armchair", "baseball", etc.).

5 Following are a series of flowcharts depicting implementations of processes. For ease of understanding, the flowcharts are organized such that the initial flowcharts present implementations via an overall "big picture" viewpoint and thereafter the following flowcharts present alternate implementations and/or expansions of the "big picture" flowcharts as either substeps or additional steps building on one or more earlier-presented
10 flowcharts. Those having ordinary skill in the art will appreciate that the style of presentation utilized herein (*e.g.*, beginning with a presentation of a flowchart(s) presenting an overall view and thereafter providing additions to and/or further details in subsequent flowcharts) generally allows for a rapid and easy understanding of the various process implementations.

15 Referring now to Figure 2, shown is a high-level logic flowchart depicting a process. Method step 200 illustrates the start of the process. Method step 202 depicts presenting at least one calibrated spoken word. Method step 204 illustrates measuring a speech reception threshold utilizing the at least one calibrated spoken word. Method step 206 shows the end of the process. In one device implementation, method step 202 is
20 achieved via a computer program, running internal to system unit 122, activating a Microsoft WAV file which is then played through headphones 140. In one device implementation, method step 204 is achieved via a computer program, running on data processing system 120, calculating the speech reception threshold in response to a test subject selecting one or more words displayed via a GUI (*e.g.*, the program calculating the
25 speech reception threshold in response to human test subject 100 selecting a word from a displayed list of words, where the selection is via a clicking on one of the spondee-labeled GUI icons of GUI 125 via mouse 128).

With reference now to Figure 3, shown is an implementation of the process depicted by the high-level logic flowchart shown in Figure 2. Depicted in Figure 3 is that

in one implementation method step 202 can include method substep 300. Illustrated is that in one implementation presenting at least one calibrated spoken word can include, but is not limited to, presenting the at least one calibrated spoken word having root-mean-squared calibration. In one device implementation, method step 300 is achieved by a presentation of a succession of sound patterns of recorded words stored in a succession of Microsoft WAV files, where each recorded word has been scaled such that the RMS energy of the wave forms of the recorded words are substantially equal, and where each recorded word matches a spondee displayed on a GUI (e.g., presenting RMS-calibrated words corresponding to the spondee-labeled icons of GUI 125). The remaining method steps of Figure 3 function substantially as described elsewhere herein.

With reference now to Figure 4, shown is an implementation of the high-level logic flowchart shown in Figure 2. Depicted in Figure 4 is that in one implementation method step 202 can include method step 400. Illustrated is that in one implementation presenting at least one calibrated spoken word can include, but is not limited to, presenting the at least one calibrated spoken word having peak value calibration. In one device implementation, method step 400 is achieved by a computer program running internal to system unit 122 making a presentation of succession of sound pattern waveforms representative of recorded words stored in Microsoft WAV files, where each recorded word has been scaled such that the maximum peak-to-peak value of the waveforms representative of the recorded words are substantially equal (those skilled in the art will appreciate that, as used herein, the maximum peak-to-peak criterion is to be representative of other peak-related criteria such as "peak-to-peak value," "positive-peak value," "maximum-absolute-peak value," etc., and that the modifications to utilize such other peak-related criteria would be well within the ambit of one having ordinary skill in the art in light of the teachings herein). The remaining method steps of Figure 4 function substantially as described elsewhere herein.

With reference now to Figure 5, shown is an implementation of the high-level logic flowchart shown in Figure 2. Depicted in Figure 5 is that in one implementation method step 202 can include method step 500. Illustrated is that in one implementation

presenting at least one calibrated spoken word can include, but is not limited to, transmitting the at least one calibrated spoken word via at least one audio speaker. In one device implementation, method step 500 is achieved by a computer program running internal to system unit 122 playing a succession of calibrated spoken words through headphones 140. The remaining method steps of Figure 5 function substantially as described elsewhere herein.

With reference now to Figure 6, shown is an implementation of the high-level logic flowchart shown in Figure 2. Depicted in Figure 6 is that in one implementation measuring a speech reception threshold utilizing the at least one calibrated spoken word (method step 204) can include, but is not limited to, method steps 600 and 602. Method step 600 illustrates accepting test subject input in response to the presented at least one calibrated spoken word. In one device implementation, method step 600 is achieved via a computer program running internal to system unit 122 accepting test subject input via the test subject selecting a word from a list of words presented via a GUI (e.g., by pointing at and selecting ("clicking on") a control on GUI 125 displayed on video display device 124 via use of mouse 128).

Method step 602 shows decreasing a speech parameter if the test subject input was substantially equal to the presented at least one calibrated spoken word. Insofar as that the objective of the speech reception test is to measure the threshold level of speech intelligibility, in one device implementation method step 602 is achieved via a computer program running internal to system unit 122 lowering, or decreasing, the gain (or, alternatively, increasing the attenuation) of a playback amplifier under the control of data processing system 120 such that the sound intensity of the words played back to human test subject 100 is decreased by a predefined amount of decibels (e.g., 5 dB). The remaining method steps of Figure 6 function substantially as described elsewhere herein.

With reference now to Figure 7, shown is an implementation of the high-level logic flowchart shown in Figure 2. Depicted in Figure 7 is that in one implementation measuring a speech reception threshold utilizing the at least one calibrated spoken word (method step 204) can include, but is not limited to, method steps 700 and 702. Method

step 700 illustrates accepting test subject input in response to the presented at least one calibrated spoken word. In one device implementation, method step 700 is achieved via acceptance of test subject input via the test subject selecting a word from a list of words presented via a GUI (e.g., by pointing at and clicking on a control on GUI 125 displayed on video display device 124 via use of mouse 128).

Method step 702 shows increasing a speech parameter if the test subject input was substantially NOT equal to the presented at least one calibrated spoken word. Insofar as that the objective of the speech reception test is to measure the threshold level of speech intelligibility, in one device implementation method step 702 is achieved via a computer program running internal to system unit 122 increasing the gain (or, alternatively, decreasing the attenuation) of a playback amplifier such that the sound intensity of the words played back to human test subject 100 is increased by a predefined amount of decibels (e.g., 5 dB). The remaining method steps of Figure 7 function substantially as described elsewhere herein.

With reference now to Figure 8, shown is an implementation of the high-level logic flowchart shown in Figure 2. Depicted in Figure 8 is that in one implementation method step 204 can include method step 800. Illustrated is that in one implementation measuring a speech reception threshold utilizing the at least one calibrated spoken word can include, but is not limited to, determining if a threshold is met in response to a history of one or more test subject inputs responsive to the presented at least one calibrated spoken word. ~~In one device implementation, method step 800 is achieved by a computer program, running internal to system unit 122, recording the number of words in succession which human test subject 100 has correctly identified, and if human test subject 100 has transitioned from not being able to identify three words in succession to being able to identify three words in succession, determining that the sound energy level at which human test subject 100 became capable of identifying the calibrated spoken words is the speech reception threshold for the individual under test.~~ The remaining method steps of Figure 8 function substantially as described elsewhere herein.

With reference now to Figure 9, shown are alternate implementations of the process depicted by the high-level logic flowchart shown in Figure 8. Depicted in Figure 9 is that in one implementation determining if a threshold is met in response to a history of one or more test subject inputs responsive to the presented at least one calibrated spoken word (method step 800) can include, but is not limited to, method step 900. Method step 900 illustrates determining the threshold via a modified Hughson-Westlake procedure. The Hughson-Westlake procedure is a procedure wherein the loudness of the played-back words is increased and/or decreased in response to whether the human test subject has/has not correctly identified the played back words. Essentially, the modified Hughson-Westlake procedure varies the playback gain such that the speech reception threshold is "bracketed," where the threshold is such that above a defined loudness the test subject can adequately discern speech, but below the defined loudness the test subject cannot adequately discern speech. Those having ordinary skill in the art will appreciate that the Hughson-Westlake procedure is ordinarily used to determine ^{audiometric thresholds} speech reception for pure ^{audio tones} tones; accordingly, since the Hughson-Westlake procedure of method step 900 is used with speech, the procedure is somewhat modified from the way in which the Hughson-Westlake procedure is ordinarily used. The Hughson-Westlake procedure is described in the Audiologists' Desk Reference, Vol. 1, pages 82-84 (1997), which is hereby incorporated by reference in its entirety. In one device embodiment, method step 900 is achieved via a computer program running internal to system unit 122.

Continuing to refer to Figure 9, further depicted in Figure 9 is that in another implementation determining if a threshold is met in response to a history of one or more test subject inputs responsive to the presented at least one calibrated spoken word (method step 800) can include, but is not limited to, method step 902. Method step 902 illustrates determining the threshold via Parameter Estimation for Sequential Testing (PEST) procedure. Essentially, the PEST procedure varies the gain such that the speech reception threshold is "bracketed," where the threshold is such that above a defined loudness the test subject can discern speech, but below the defined loudness the test subject cannot discern speech, where the variation is adaptive to user responses during testing. The

PEST procedure is described in M.M. Taylor, PEST: Efficient Estimates on Probability Function, The Journal of the Acoustical Society of America, Vol. 41, No. 4, pages 782-787 (Jan. 1967), which is hereby incorporated by reference in its entirety. The remaining method steps of Figure 9 function substantially as described elsewhere herein. In one
5 device embodiment method step 902 is achieved via a computer program running internal to system unit 122.

Those having ordinary skill in the art will recognize that the state of the art has progressed to the point where there is little distinction left between hardware and software implementations of aspects of systems; the use of hardware or software is
10 generally (but not always, in that in certain contexts the choice between hardware and software can become significant) a design choice representing cost vs. efficiency tradeoffs. Those having ordinary skill in the art will appreciate that there are various vehicles by which processes and/or systems described herein can be effected (*e.g.*, hardware, software, and/or firmware), and that the preferred vehicle will vary with the context in which the
15 processes are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a hardware and/or firmware vehicle; alternatively, if flexibility is paramount, the implementer may opt for a solely software implementation; or, yet again alternatively, the implementer may opt for some combination of hardware, software, and/or firmware. Hence, there are several possible vehicles by
20 which the processes described herein may be effected, none of which is inherently superior to the other in that any vehicle to be utilized is a choice dependent upon the context in which the vehicle will be deployed and the specific concerns (*e.g.*, speed, flexibility, or predictability) of the implementer, any of which may vary.

The foregoing detailed description has set forth various embodiments of the
25 devices and/or processes via the use of block diagrams, flowcharts, and examples. Insofar as such block diagrams, flowcharts, and examples contain one or more functions and/or operations, it will be understood as notorious by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or

virtually any combination thereof. In one embodiment, the present invention may be implemented via Application Specific Integrated Circuits (ASICs). However, those skilled in the art will recognize that the embodiments disclosed herein, in whole or in part, can be equivalently implemented in standard Integrated Circuits, as one or more computer
5 programs running on one or more computers (*e.g.*, as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (*e.g.*, as one or more programs running on one or more micro-processors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and or firmware would be well within the skill of one of ordinary
10 skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the present invention are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the present invention applies equally regardless of the particular type of signal bearing media used to actually carry out the distribution. Examples of signal bearing media include, but are not limited to,
15 the following: recordable type media such as floppy disks, hard disk drives, CD ROMs, digital tape, and computer memory; and transmission type media such as digital and analogue communication links using TDM or IP based communication links (*e.g.*, packet links).

In a general sense, those skilled in the art will recognize that the various
20 embodiments described herein which can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or any combination thereof can be viewed as being composed of various types of "electrical circuitry." Consequently, as used herein "electrical circuitry" includes, but is not limited to, electrical circuitry having at least one discrete electrical circuit, electrical circuitry having at least one integrated circuit,
25 electrical circuitry having at least one application specific integrated circuit, electrical circuitry forming a general purpose computing device configured by a computer program (*e.g.*, a general purpose computer configured by a computer program which at least partially carries out processes and/or devices described herein, or a microprocessor configured by a computer program which at least partially carries out processes and/or

devices described herein), electrical circuitry forming a memory device (e.g., forms of random access memory), and electrical circuitry forming a communications device (e.g., a modem, communications switch, or optical-electrical equipment).

Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use standard engineering practices to integrate such described devices and/or processes into data processing systems. That is, the devices and/or processes described herein can be integrated into a data processing system via a reasonable amount of experimentation. Figures 1A-1E show an example representation of a data processing system into which at least a part of the herein described devices and/or processes may be integrated with a reasonable amount of experimentation.

With reference now again to Figures 1A-E, depicted is a pictorial representation of a conventional data processing system in which portions of the illustrative embodiments of the devices and/or processes described herein may be implemented. It should be noted that graphical user interface systems (e.g., Microsoft Windows 98, or Microsoft Windows NT, or Microsoft Windows XP operating systems) and methods can be utilized with the data processing system depicted in Figures 1A-1E. Data processing system 120 is depicted which includes system unit 122, video display devices 124, 164, keyboard 166, mice 128, 170, and microphone 168. Data processing system 120 may be implemented utilizing any suitable commercially available computer system.

The foregoing described embodiments depict different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely exemplary, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being

"operably connected", or "operably coupled", to each other to achieve the desired functionality.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (*e.g.*, bodies of the appended claims) are generally intended as "open" terms (*e.g.*, the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (*e.g.*, "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean *at least* the recited number (*e.g.*, the bare recitation of "two recitations," without other modifiers, typically means *at least* two recitations, or *two or more* recitations).

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.